



HIGH PERFORMANCE AEROGEL INSULATION FOR SHELTERS



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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UNCLASSIFIED

- Army Priorities
- Current Insulation
- Objectives
- Definition of Aerogel
- Challenges and Breakthroughs
- Program History
- Testing and Evaluation
- Future Plans

Army is looking to:

- “Go Green”
- Reduce fuel consumption
- Reduce logistical footprint of Forward Operating Base Camps (FOBs)
- Minimize number of convoys needed to resupply fuel (which reduces risk of Soldier exposure to IEDs, etc.)



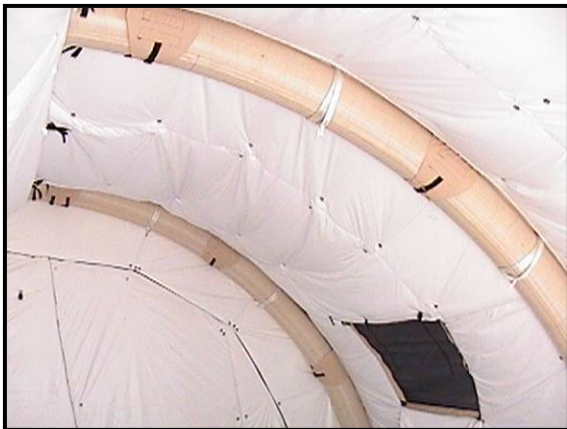
- Majority of Army soft wall shelters do not have insulation
- Insulation that is available is considered heavy and bulky
- Difficult to transport and integrate within shelters
- Polyurethane (PU) external foam insulation is now available, but not practical for expeditionary use



Tent sprayed with PU foam insulation

Looking to develop a high performance insulation that is:

- Lightweight
- Low cube
- Easy to install or already integrated
- Safe for Soldier use
- Meets Army regulations and guidelines



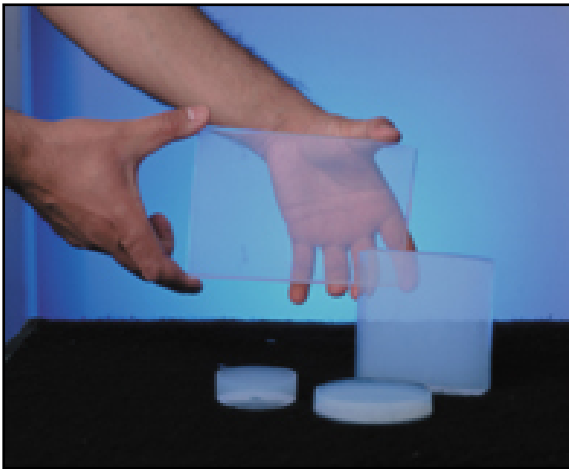
Integrated Aerogel Liner



Current Insulation

Aerogel Insulation

- Aerogels are nanoporous solids invented in the 1930's
 - Aerogels are created when silica is gelled in a solvent
 - When the solvent is removed, what remains is “puffed-up sand”, with up to 99% porosity
 - Nanoporosity slows heat and mass transport, providing record-low thermal conductivity
 - Nano-scale lattice and pores create unique properties
 - Pore diameters $< 1/500$ th the width of a human hair



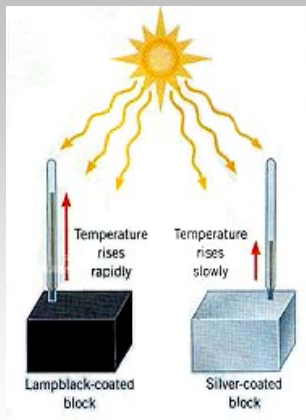
Aerogels are often called “frozen smoke”

$$\text{Total Thermal Transport} = \text{Conduction} + \text{Convection} + \text{Radiation}$$

Structural Benefits of Aerogel

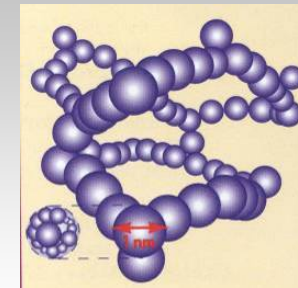
- Nano sized porosity
- Convolutated matrix
- Aerogels 95 - 97% air
- Opacification

Radiation



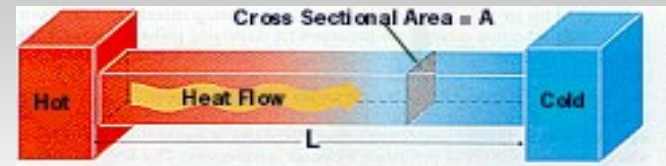
Opacification = Radiation path is blocked

Convection



Limited air movement = minimal convection

Conduction



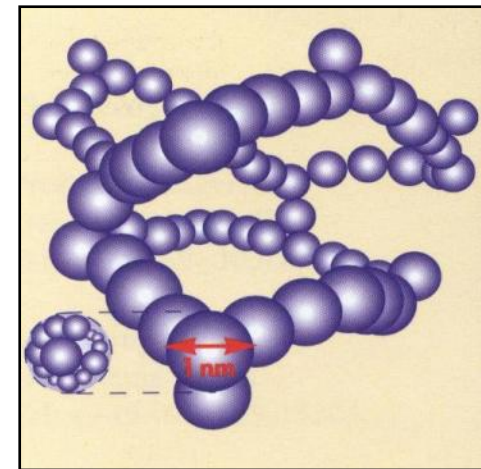
Low mass = minimal conduction

Challenges:

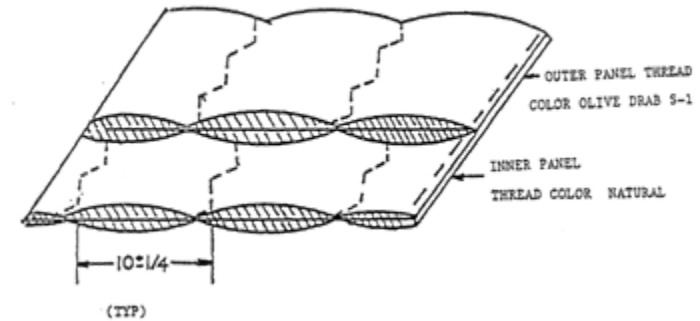
- Aerogel is normally rigid, making it unsuitable for soft wall shelter use.
- The typical manufacturing process for aerogel is quite lengthy, taking up to months to dry the solvent.

Breakthroughs:

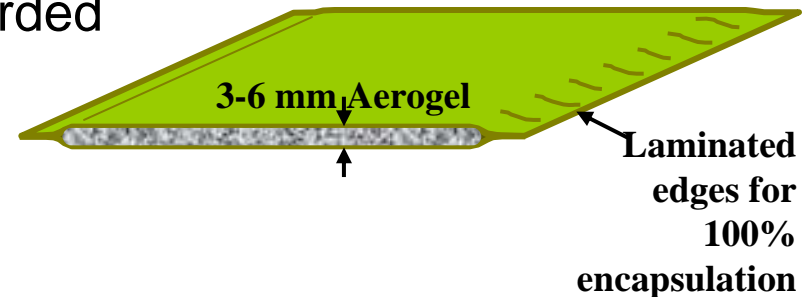
- Casting the wet gel into a fibrous batting provides mechanical integrity – flexible blanket form
- Supercritical CO₂ extraction process reduces cycle time from months to hours



- **Jan 2003**—Phase I SBIR program awarded
- Initial Targets:
 - Weight (max): 23.0 oz/yd²
 - Width: 54 ± 1.0 in.
 - Thickness: @ 0.002 psi (max) 2.0 in.
 - R-value: 3.2 F-ft²-Hr/Btu



- **Feb 2005**—Phase II SBIR program awarded
- Modular Command Post (MCP) Tests
 - Outdoor tests at NB
 - Chamber tests at Eglin AFB
 - Chamber tests at NSRDEC



- **Feb 2007**—Phase II Plus Awarded
- Rapid Equipping Force (REF) procures 10 aerogel tents for field tests in Afghanistan

- **Integrated Modular Command Post (MCP):**
 - **Dimensions:** 11 ft x 11 ft
 - **Fabric Weight:** 131 lbs
 - **Polyester lofted Liner Weight:** 115 lbs
 - **Total Fabric Weight with Lofted Polyester Liner:** 246 lbs
 - **Aerogel Lined Tent Weight:** 195 lbs*
- *21% weight savings!!**



Outdoor Cold Temperature Tests at Aspen Aerogels, Northborough, MA

- **Objective:** Collect initial data on aerogel tent insulation performance in cold weather
- **Conditions:** 24° F Ambient with no direct sunlight on tents (early morning hours)

Tests at McKinley Climatic Chamber Eglin Air Force Base, FL

- **Objective:** Validate MCP performance seen in outdoor tests. Determine both hot and cold weather performance in controlled environment
- **Conditions** 1) -25° F ambient with no solar load on tents
2) 125° F ambient with no solar load on tents

Tests at Doriot Climatic Chamber NSRDEC, MA

- **Objective:** Retest MCP performance with better fidelity. Accurately compare MCP lofted insulation system to aerogel encapsulated system in hot temperatures.
- **Conditions:** 120° F ambient with no solar load on tents



Conclusions from Aerogel Integrated MCP Testing



- **Estimate ~30-40+% reduction in fuel consumption for heating/cooling**
 - System will pay for itself in 3-6 months
- **More accurate and efficient environmental control**
 - Extends life and performance of sensitive electronics and batteries
- **Aerogel insulation provides significant IR signature reduction**
 - IR thermal images demonstrate not only the extreme insulating power of the Aerogel insulated MCP roof, but also the IR Suppression capabilities of the new roof system
- **Insulation system is fully integrated into tent structure**
 - Packs in existing transport bag (no increase in transport cube)
 - **13% increase in system weight vs. 23% increase with polyester liner**
 - No additional parts or assembly required
- **Efficient retrofit to existing units in the field**
 - Liner assembly fits existing MCP units in the field

•Test Equipment

- Vertigo Advanced Medical Shelter (ADMS)
- SL6251 aerogel liner (placed against tent skin)
- Improved Army Space Heater (IASH)

•Test Plan & Configurations

Goal:

Directly compare fuel consumption rate of an uninsulated tent to that of a tent with aerogel insulation

Duration:

96 hours of consistent heating Operations

Conditions:

- Ambient temperature between 24° F and 45° F
- Internal temperature maintained at ~65° F

Configurations:

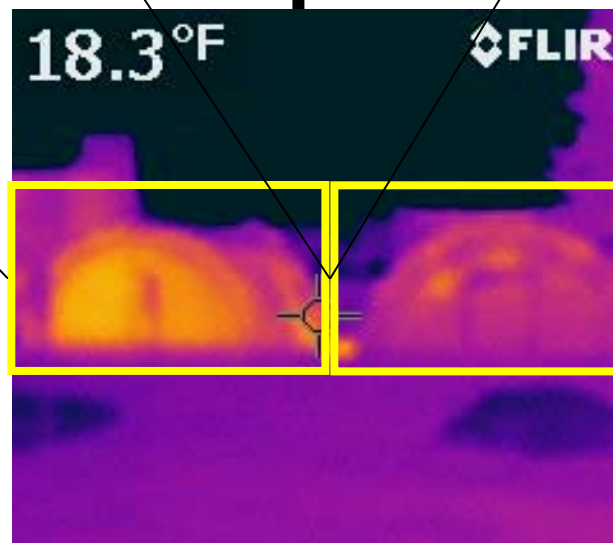
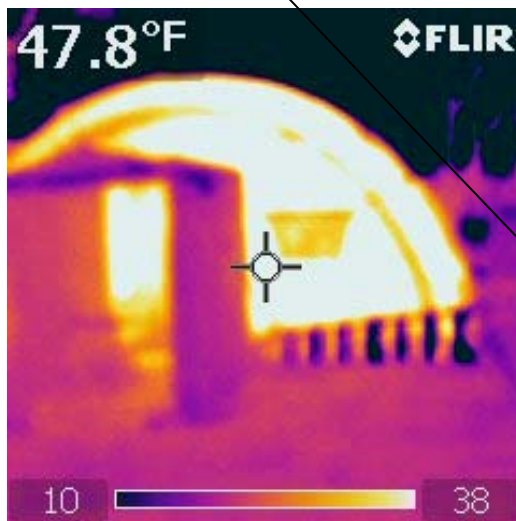
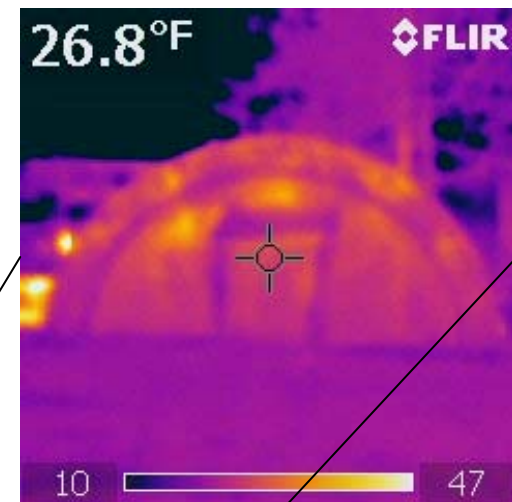
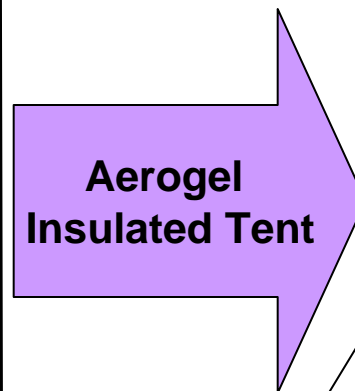
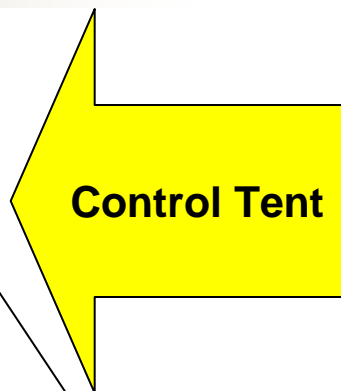
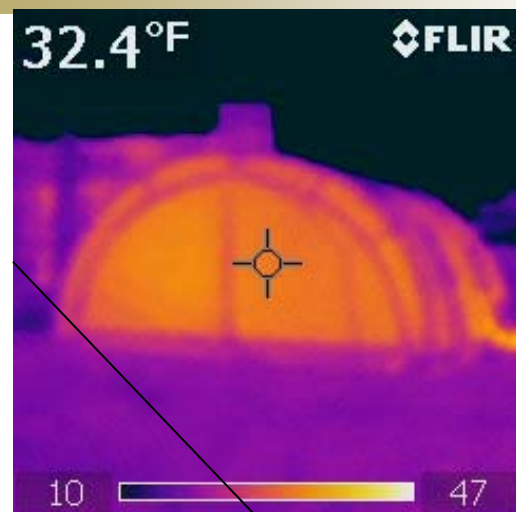
- Baseline--ADMS tent with no liner
- Aerogel insulated tent—ADMS tent with full aerogel liner



Vertigo ADMS Shelter



Improved Army Space Heater (IASH)



- Non-insulated shelter:
 - Test duration: 91.25 hrs
 - Average temperature maintained: 65°F
 - Interior surface area: 1393.89 ft²
 - BTUs: 3,170,000
- Insulated shelter:
 - Test duration: 91.25 hrs
 - Average temperature maintained: 67°F
 - Interior surface area: 1393.89 ft²
 - BTUs: 2,080,000
- Final Report Conclusions:
 - The overall percentage of fuel savings was calculated to be **34.1%** during the test period.

- Aspen Aerogels is currently fabricating two aerogel liner prototypes for NSRDEC: one for a 32' Airbeam TEMPER and another for a 32' frame TEMPER
- NSRDEC is planning to include one aerogel liner for test and evaluation through the Net Zero Plus, JCTD organized by CERDEC.



Questions??